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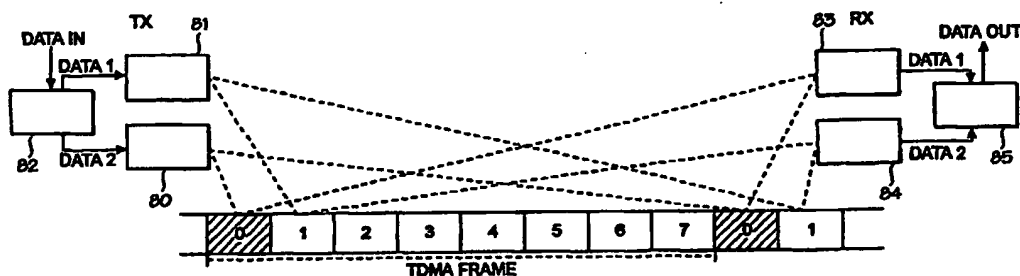
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International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : <b>H04Q 7/22</b>		A1	(11) International Publication Number: <b>WO 95/31878</b>
			(43) International Publication Date: 23 November 1995 (23.11.95)
(21) International Application Number: <b>PCT/FI95/00248</b>		(81) Designated States: AU, CN, DE, GB, JP, NO, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
(22) International Filing Date: 10 May 1995 (10.05.95)			
(30) Priority Data: 942190 11 May 1994 (11.05.94) FI		Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments. In English translation (filed in Finnish).	
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(54) Title: METHOD AND ARRANGEMENT FOR HIGH-SPEED DATA TRANSMISSION IN A TDMA MOBILE TELECOMMUNICATIONS SYSTEM



(57) Abstract

The present invention relates to a method for improving data transmission in a mobile telecommunications system, in which method data is transmitted over the radio path between a mobile station (MS) and a base station (BTS) as bursts in time slots allocated to the mobile station by successive frames. In the invention, a divider (82) splits a data signal (DATAIN) whose speed is higher than the maximum data transfer rate in one frame into at least two signals of lower speed (DATA1, DATA2) before transmission over the radio path. The mobile station (MS) is allocated at least two time slots in each successive frame for high-speed data transmission so that each of said signals of lower speed (DATA1, DATA2) is transmitted over the radio path in its respective time slot. A combiner (85) combines the signals of lower speed (DATA1, DATA2) received over the radio path into the original signal.

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Method and arrangement for high-speed data transmission  
in a TDMA mobile telecommunications system

The present invention relates to a method for  
improving data transmission in a mobile  
telecommunications system, in which method data is  
transmitted over the radio path between a mobile station  
and a base station as bursts within time slots allocated  
to the mobile station in successive frames.

#### Background of the Invention

In mobile telecommunications systems of the time  
division multiple access (TDMA) type, time division  
communication in the radio path takes place in  
successive TDMA frames each of which consists of several  
time slots. In each time slot, a short information  
packet is sent as a radio frequency burst of a finite  
duration, which burst consists of a number of modulated  
bits. For the most part, time slots are used for the  
transmission of control channels and traffic channels.  
On the traffic channels, speech and data are  
transmitted. On the control channels, signalling between  
a base station and mobile subscriber stations is carried  
out. The Pan-European mobile system GSM (Global System  
for Mobile Communications) is an example of a TDMA radio  
system.

For communication in conventional TDMA systems,  
each mobile station is assigned one time slot of traffic  
channel for data or speech transmission. Thus, a GSM  
system, for example, can have as much as eight  
simultaneous connections to different mobile stations  
on a same carrier frequency. The maximum data transfer  
rate on a traffic channel is restricted to a relatively  
low level according to the bandwidth in use as well as  
channel coding and error correction, for example in a  
GSM system to 9,6 kbit/s or 12 kbit/s. In addition, in

a GSM system a half-speed traffic channel (max. 4,8 kbit/s) can be chosen for low speeds of speech coding. The half-speed traffic channel is established when a mobile station communicates in a specific time slot only in every second frame, in other words, in half-speed. A second mobile station communicates in every second frame in the same time slot. This is how the capacity of the system can be doubled as far as the number of subscribers is concerned, in other words, on the same carrier wave it is possible for up to 16 mobile stations to communicate simultaneously.

In the last few years, the need for high-speed data services in mobile communication networks has remarkably increased. Data transfer rates of at least 64 kbit/s would be needed to utilize, for example, ISDN (Integrated Services Digital Network) circuit switched digital data services. PSTN data services of the public telephone network, such as modems and telefax terminals of class G3, require faster transfer rates, such as 14,4 kbit/s. One of the growing areas of mobile data transfer requiring higher transfer rates is the mobile video service. As examples of this kind of services, security control by cameras and video databases can be mentioned. The minimum data transfer rate in video transfer can be, for example, 16 or 32 kbit/s.

The data transfer rates of the present mobile communication networks are not, however, sufficient to satisfy this kind of new needs.

#### Summary of the Invention

It is an object of the present invention to enable higher data transfer rates in mobile communication networks.

The object is achieved in a mobile telecommunications system of the type illustrated in the

introductory section by a method which according to the present invention is characterized by

splitting a high-speed data signal into two or more signals of lower speed prior to a transmission over the radio path,

allocating, for high-speed data transmission, a mobile station at least two time slots from each frame corresponding to the number of said signals of lower speed,

transmitting each data signal of lower speed in different one of the time slots.

The invention further relates to an arrangement for high-speed data transmission in a mobile telecommunications system in which data is transmitted over the radio path between a mobile station and a base station as bursts in time slots allocated to a mobile station by successive frames. According to the invention, it is characteristic of the arrangement that it comprises means for splitting a data signal whose speed is higher than the maximum data transfer rate in a time slot into two or more signals of lower speed prior to transmission over the radio path, and that a mobile station is allocated two or more time slots in each successive frame for high-speed data transmission so that each of said signals of lower speed is transmitted over the radio path in its respective time slot, and means for combining the signals of lower speed received over the radio path.

The invention employs a so-called multi-slot technique so that a mobile station has access to two or more time slots in each frame. The high-speed data signal to be transmitted over the radio path is split into a required number of data signals of lower speed, each signal being transmitted as bursts in a respective time slot. As soon as the data signals of lower speed

have separately been transmitted over the radio path, they are again at the receiving end combined into the original high-speed signal. This is how the data transfer rate can be doubled, tripled, etc., depending on whether two, three or more time slots are assigned to be used by a subscriber. In a GSM system, for example, two time slots will enable a data transfer speed of  $2 \times 9,6$  kbit/s which is enough for a modem of 14,4 kbit/s, or a telefax terminal, for example. Six time slots will enable a data transfer rate of 64 kbit/s.

The multi-slot technique in accordance with the invention, in which a high-speed data signal is transmitted as several bursts in several time slots within one frame, has many advantages over an alternative approach in which a mobile station is also assigned several time slots in the same frame for data transmission, but the whole data signal is transmitted as one burst extended for the time of the assigned time slots. In the present invention, there is no need to change the other significant characteristics of the physical transmission path (radio path, for example, Layer 1 of GSM), such as frequency division, frame format and time slot configuration, data transfer rate, error correction, modulation, format of a TDMA burst, bit error ratio (BER), etc. In other words, by the present invention it is possible to support different kind of subscriber data transfer rates in the radio system by a single structure of a physical transmission path. Consequently there is no need to support several structures of a physical transmission path by the subscriber terminals, either.

By handling each of the several time slots as an independent traffic channel, a simple implementation is possible as channel coding, interleaving, burst building

and modulation operations can separately be carried out to each signal of lower speed. Thus, carrying out different kinds of channel codings and interleavings which depend on the required data transfer rates can be avoided. The simple embodiment is especially advantageous in cases the multi-slot technique in accordance with the invention is applied to existing systems, such as the GSM.

The implementation may be especially simple if adjacent time slots are employed. Consequently, it will be easier to carry out various measurements the remaining part of the frame, and increasing the number of frequency synthesizers in the receiver of the mobile station is avoided. In the GSM system, it is especially advantageous to implement the invention by two time slots.

#### Brief Description of the Drawings

In the following, the invention will be described in greater detail by the primary embodiments with reference to the accompanying drawings in which

Figure 1 illustrates a section of a mobile system in which the invention can be applied, and

Figures 2, 3, 4 and 5 illustrate a TDMA frame format,

Figure 6 illustrates a TCH/F+SACCH multiframe,

Figure 7 illustrates a conventional data transmission in one time slot,

Figure 8 illustrates data transmission in accordance with the invention in two time slots,

Figure 9 illustrates the timing of transmission, reception and measurements in a data transmission of one time slot,

Figure 10 illustrates the timing of transmission, reception and measurements in a data transmission of two time slots.



### The Preferred Embodiments of the Invention

The present invention can be applied to high-speed data transmission in most of the digital mobile systems of the TDMA type such as, for example, the Pan-European digital mobile system GSM, DSC1800 (Digital Communication System), UMTS (Universal Mobile Telecommunication System), FPLMTS (Future Public Land Mobile Telecommunication System), etc.

A mobile system of the GSM type is illustrated as an example. GSM (Global System for Mobile Communications) is a Pan-European mobile system. Figure 1 very briefly illustrates the basic elements of the GSM system without going any further into the details or other sub-sections of the system. For a closer description of the GSM system, the GSM recommendations and "The GSM System for Mobile Communications", by M. Mouly & M. Pautet, Palaiseau, France, 1992, ISBN: 2-9507190-0-7 is referred to.

A mobile services switching centre MSC handles the connecting of incoming and outgoing calls. It performs functions similar to those of an exchange of a public telephone network (PSTN). In addition to these, it also performs functions characteristic of mobile communications only, such as subscriber location management in co-operation with the subscriber registers of the network. As subscriber registers, the GSM system at least includes the home location register HLR and the visitor location register VLR which are not shown in figure 1. More accurate information of the location of the subscriber, usually the accuracy of the location area, is stored in the visitor location register, there being typically one VLR per each mobile services switching centre MSC, while the HLR knows which VLR area the mobile station MS is visiting. The mobile stations MS are connected to the centre MSC by base station

systems. The base station system consists of a base station controller BSC and base stations BTS. One base station controller is used to control several base stations BTS. The tasks of the BSC include, among other things, handovers in cases in which the handover is performed within the base station, or between two base stations controlled by the same BSC. Figure 1 only shows, for reasons of clarity, a base station system in which nine base stations BTS1-BTS9 are connected to a base station controller BSC, the radio coverage area of which base stations forms the corresponding radio cells C1-C9.

The GSM system is a time division multiple access (TDMA) system in which the time division traffic on the radio path takes place in successive TDMA frames each of which consists of several time slots. In each time slot, a short information packet is sent as a radio frequency burst of a finite duration, which burst consists of a number of modulated bits. For the most part, time slots are used for the transmission of control channels and traffic channels. On the traffic channels, speech and data are transmitted. On the control channels, signalling between a base station and mobile subscriber stations is carried out.

Channel structures used in radio interface of the GSM system are described in closer detail in the ETSI/GSM recommendation 05.02. The TDMA frame format of a the GSM system is illustrated as an example in figures 2-5. Figure 5 illustrates a TDMA basic frame which includes eight time slots 0-7 used as traffic channels or control channels. Thus, only one radio frequency burst shorter than the duration of the time slot is transmitted in each time slot. As soon as one TDMA basic frame ends in time slot 7, the time slot 0 of the next basic frame immediately begins. Thus, 26 or 51

successive TDMA frames form a multiframe depending on whether a traffic channel or a control channel structure is in question, as illustrated in figure 4. A superframe consists of 51 or 26 successive multiframe depending on whether the multiframe have 26 or 51 frames, as illustrated in figure 3. A hyperframe is formed of 2048 superframes, as illustrated in figure 2. The hyperframe is the biggest successive frame unit whose ending starts a new, similar hyperframe.

Figure 6 illustrates a structure of a full-speed traffic channel TCH/F-SACCH/TF defined by the recommendation, in which structure a multiframe includes 24 full-speed traffic channel frames TCH, one parallel control channel frame SACCH and a dummy frame IDLE. In each time slot assigned to be used as traffic channels, the control channel SACCH and a dummy time slot are repeated every 26 time slots. The positions of the frames SACCH and IDLE are different for time slots 0, 2, 4 and 6 than for time slots 1, 3, 5, and 7. What is illustrated in figure 7 is valid for time slots 0, 2, 4 and 6. In time slots 1, 3, 5 and 7, frames IDLE and SACCH exchange places. The control channel SACCH is used for reporting the measurement results from the mobile station to the fixed radio network, and for controlling of the mobile station, for example, power adjustment, from the fixed radio network.

In normal operation, at the beginning of a call a mobile station MS is assigned one time slot from a carrier wave as a traffic channel (single slot access). The mobile station MS synchronizes into this time slot to transmit and receive radio frequency bursts. In figure 7, for example, a mobile station MS is locked to the time slot 0 of a frame. Channel coding, interleaving, burst formation, and modulation are carried out to the data to be transmitted DATAIN, after

which operations the radio frequency burst is transmitted in the time slot 0 of each TDMA frame. In the remaining part of the frame, the MS carries out various kinds of measurements, as will be described below.

In accordance with the invention, a mobile station MS requiring data transmission of higher speed than one traffic channel can offer, is assigned two or more time slots from the same frame.

The multi-slot technique according to the invention requires certain additional features in the signalling in connection with traffic channel allocation. During the call set-up time, assigning a traffic channel to a mobile station is carried out by an assignment command which is transmitted to the mobile station by the fixed network. This message must contain the data of all the traffic channels that are assigned to a mobile station MS for high-speed data transmission according to the invention. Already by now, the GSM system must be able to address two half-speed traffic channels in the same assignment command, which is why the message contains descriptions and modes for both the first as well as the second traffic channel. The present assignment command can easily be expanded to cover the addressing of at least two time slots, i.e. full-speed traffic channels. An assignment command is described in the GSM recommendation 04.08, version 4.5.0, June 1993, pp. 168-170. Channel addressing in accordance with the invention can be performed in the assignment command data elements Mode of first channel, mode of second channel, and Channel Description Information element, which are described in greater detail in the GSM recommendation 04.08, version 4.5.0, June 1993, pp. 316-350. For addressing more than two time slots, a new message must be determined. Due to the fact that all the

channels addressed are of the same type of channel, TCH/F, the message can be limited to describe the type of the first channel and then the total number of channels required. In such a case, the message would be rather short and simple.

Correspondingly, in case of a handover, the handover command must be able to address two or more time slots in the same frame. In the GSM system, the handover command contains the same data fields as described above in connection with the assignment command, and thus it can be applied to the requirements of the invention with similar changes. The handover command is described in the GSM recommendation 04.08, version 4.5.0, June 1993, pp. 184-189.

A second alternative is to employ a dedicated assignment command for each time slot.

In both cases, both outgoing and incoming call set-up messages (SETUP) of a mobile station must contain information about the actual channel requirements, in other words, the number of time slots needed. This information may be included in the Bearer Capability Information element BCIE. The BCIE is described in the GSM recommendation 04.08, version 4.5.0, pp. 423-431.

Figure 8 shows an example in which a mobile station MS is assigned successive time slots 0 and 1 from the same TDMA frame. A high-speed data signal DATAIN to be transferred over the radio path is split in the divider 82 into a necessary number of data signals of lower speed DATA1 and DATA2. Channel coding, interleaving, burst formation and modulation 80, and, correspondingly, 81, are separately carried out to each data signal of lower speed DATA1 and DATA2, after which each data signal is transmitted as a radio frequency burst in its dedicated time slot 0 and 1, respectively. As soon as the lower speed data signals DATA1 and DATA2

are separately transmitted over the radio path, demodulation, deinterleaving and channel decoding 83 and, correspondingly, 84, of the signals are separately performed at the receiving end, after which the signals  
5 DATA1 and DATA2 are combined into the original high-speed signal DATAOUT in the combiner 85 at the receiving end.

On the fixed network side, the functions of blocks 80, 81, 83, 84 of figure 8, in other words, channel  
10 coding, interleaving, burst formation and modulation, and, correspondingly, demodulation, deinterleaving and channel decoding are located advantageously at the base station BTS. The base station BTS has a separate, parallel handling for each time slot. The divider 82 and  
15 the combiner 85 can, in turn, be assigned, as needed, to any network element such as a base station BTS, a base station controller BSC, or a mobile services switching centre MSC. In cases the divider 82 and the combiner 85 are located in another network element than  
20 the base station BTS, the data signals of lower speed DATA1 and DATA2 are transmitted between that element and the base station BTS similarly to signals on normal traffic channels.

In a fixed network of the GSM system, various  
25 functions relating to speech coding and rate adaptation are concentrated in a TRCU (Transcoder/Rate Adaptor Unit). The TRCU may be located in several alternative places in the system according to choices made by the manufacturer. Typically, the TRCU is placed at the  
30 mobile services switching centre MSC, but it may also be a part of a base station controller BSC or a base station BTS. In cases the TRCU is placed apart from a base station BTS, information is transmitted between the base station and the transcoder/rate adaptor unit TRCU  
35 in so-called TRAU frames. The function of the

transcoder/rate adaptor unit is defined in the GSM recommendation 08.60. A combiner 85 and a divider 83 in accordance with the invention may be placed with this transcoder/rate adaptor unit TRCU.

5           In a mobile station MS, the blocks 80, 81, 83 and 84 of figure 8, in other words, channel coding, interleaving, burst formation and modulation, and, correspondingly, demodulation, deinterleaving and channel decoding, are advantageously implemented by a  
10           processing unit common to all time slots, at least in an embodiment of two time slots.

          The use of two adjacent time slots in the same frame results in the simplest implementation of a mobile station MS due to, above all, the number of frequency  
15           synthesizers needed. This can be illustrated by figures 9 and 10.

          In figure 9, a mobile station is in a normal manner locked in the time slot 0 of a frame, and carries measurements during the other time slots. Between the  
20           downlink direction (BTS to MS) and the uplink direction (MS to BTS) there is an offset of three time slots in the time slot numbering so that the reception is not interfered with by own transmission. Transmitting time (TX) of approximately 1,5 time slots is shown. This is  
25           due to the fact that the actual transmission can take place within this range depending on the timing advance used for compensating the transmission delay caused by the distance between the base station and the mobile station. There are at least 1,5 time slots between  
30           transmission and reception (RX) in order to leave an adequate settling time for the MS frequency synthesizer which generates local oscillator signals for transmission and reception. This means that only one frequency synthesizer is required for transmission and  
35           reception.

Figure 10 shows a case in which a mobile station MS is assigned two adjacent time slots in each frame for high-speed data transmission according to the present invention. A second time slot 1 immediately follows the first time slot in both RX and TX directions. By placing two time slots in succession like this, it is ensured that RX and TX operations do not overlap by which distinct advantages can be achieved. A frequency synthesizer would not, however, have enough time to settle between all the TX and RX operations, which means that separate frequency synthesizers are required, one for receiving and one for transmitting, unless very fast frequency synthesizers are employed.

In cases the number of time slots increases to more than two, RX and TX operations do overlap and full duplex filtering is required. As a result, the measurement moment can be set more freely, which is why two frequency synthesizers is still adequate for three or four time slots, possibly even five, as the same synthesizer can be used for both reception and measuring operations. An implementation of six time slots already requires separate frequency synthesizers for reception as well as measuring operations, unless very fast frequency synthesizers are employed.

The figures and the explanation in connection with them are only meant to illustrate the present invention. The method and arrangement in accordance with the invention may vary within the scope of the attached claims.



## Claims

1. A method for high-speed data transmission in a mobile telecommunications system, in which method  
5 data is transmitted over the radio path between a mobile station and a base station as bursts in a time slot allocated to the mobile station by successive frames, c h a r a c t e r i z e d by  
10 splitting a high-speed data signal into two or more signals of lower speed prior to a transmission over the radio path,  
allocating, for high-speed data transmission, a mobile station at least two time slots from each frame corresponding to the number of said signals of lower  
15 speed,  
transmitting each data signal of lower speed in different one of the time slots.
2. A method as claimed in claim 1, c h a r a c t e r i z e d by allocating a mobile station adjacent  
20 time slots in a frame.
3. A method as claimed in claim 1 or 2, comprising steps of  
carrying out channel coding, interleaving, burst formation and modulation operations to a data signal to  
25 be transmitted,  
carrying out demodulation, deinterleaving and channel decoding operations to a received data signal, c h a r a c t e r i z e d by  
30 carrying out said channel coding, interleaving, burst formation and modulation operations separately to each signal of lower speed.
4. A method as claimed in claim 1, 2 or 3, c h a r a c t e r i z e d by splitting a data signal to be transmitted to a mobile station into signals of lower  
35 speed at a base station.

5. A method as claimed in claim 1, 2 or 3, c h a -  
r a c t e r i z e d by splitting a data signal to be  
transmitted to a mobile station into signals of lower  
speed somewhere else than the base station, and  
5 transmitting said data signal to the base station as  
signals of lower speed.

6. An arrangement for high-speed data transmission  
in a mobile telecommunications system in which data is  
transmitted over the radio path between a mobile station  
10 (MS) and a base station (BTS) as bursts in time slots  
allocated to a mobile station by successive frames,  
c h a r a c t e r i z e d it that it comprises means  
(82) for splitting a data signal (DATAIN) whose speed  
is higher than the maximum data transfer rate in a time  
slot into two or more signals of lower speed (DATA1,  
15 DATA2) prior to transmission over the radio path, and  
that a mobile station (MS) is allocated two or more time  
slots in each successive frame for high-speed data  
transmission so that each of said signals of lower speed  
20 (DATA1, DATA2) is transmitted over the radio path in its  
respective time slot, and means (85) for combining the  
signals of lower speed (DATA1, DATA2) received over the  
radio path.

7. An arrangement as claimed in claim 6, c h a -  
25 r a c t e r i z e d in that a mobile station is  
allocated adjacent time slots in a frame.

8. An arrangement as claimed in claim 6 or 7, in  
which arrangement both a mobile station and a base  
station comprise means for performing channel coding,  
interleaving, burst formation and modulation operations  
30 to the data to be transmitted, and means for  
demodulation, deinterleaving and channel decoding  
operations of the received signal, c h a r a c t e r -  
i z e d by means (80, 81, 83, 84) for performing channel  
35 coding, interleaving, burst formation and modulation

operations separately to each signal of lower speed (DATA1, DATA2).

5 9. An arrangement as claimed in claim 6, 7 or 8, characterized in that means for combining and dividing (82, 85) are placed at a base station (BTS) and a mobile station (MS).

10 10. An arrangement as claimed in claim 6, 7 or 8, characterized in that means for combining and dividing (82, 85) are placed at a centre (MSC) and a mobile station (MS).

15 11. An arrangement as claimed in claim 6, 7 or 8, characterized in that a mobile telecommunications system is a GSM system, and in that means for combining and dividing are placed at a transcoder and a mobile station.

20 12. An arrangement as claimed in any one of claims 6-11, characterized in that a base station (BTS) has means (80, 81, 83, 84) for channel coding, interleaving, burst formation and modulation operations separately to each signal of lower speed.

25 13. An arrangement as claimed in any one of claims 6-12, characterized in that a mobile station (MS) has means (80, 81, 83, 84) common to all signals of lower speed for channel coding, interleaving, burst formation and modulation operations.

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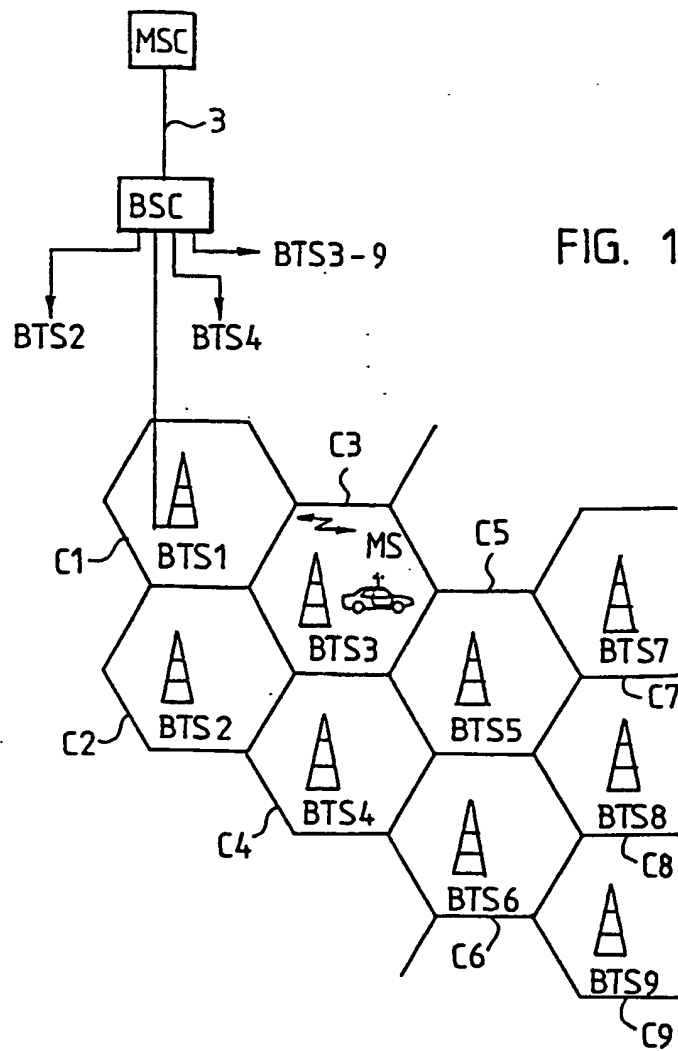


FIG. 1

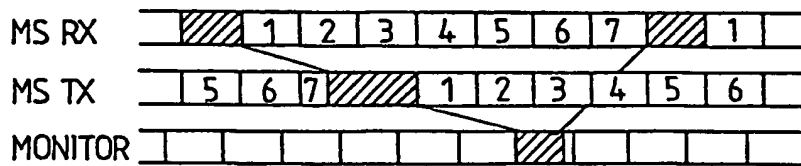


FIG. 9

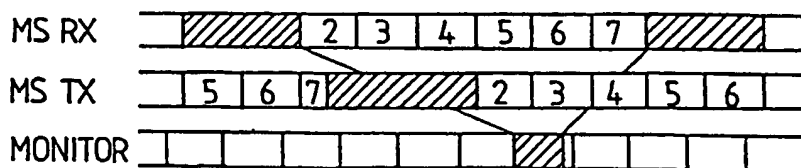
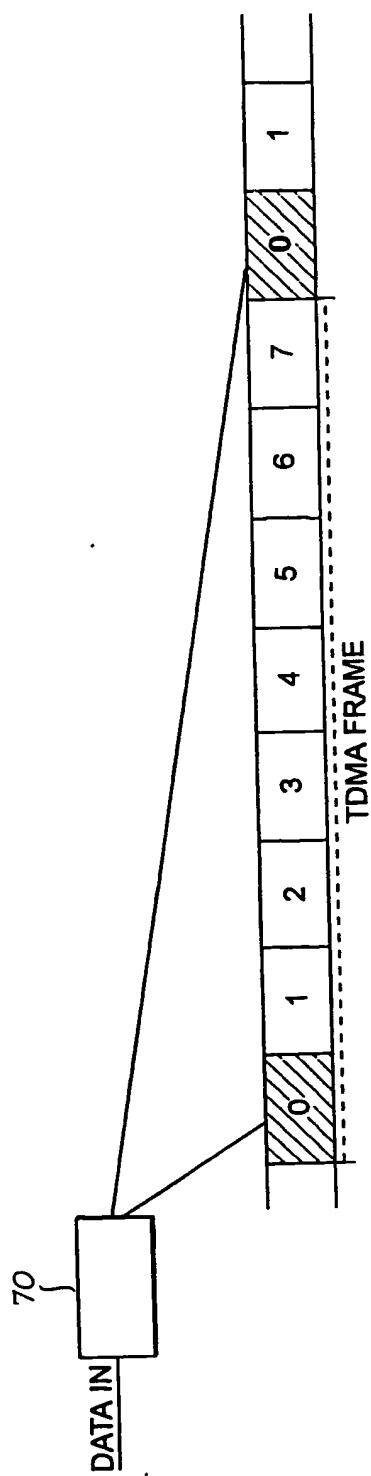


FIG. 10



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**FIG. 7**

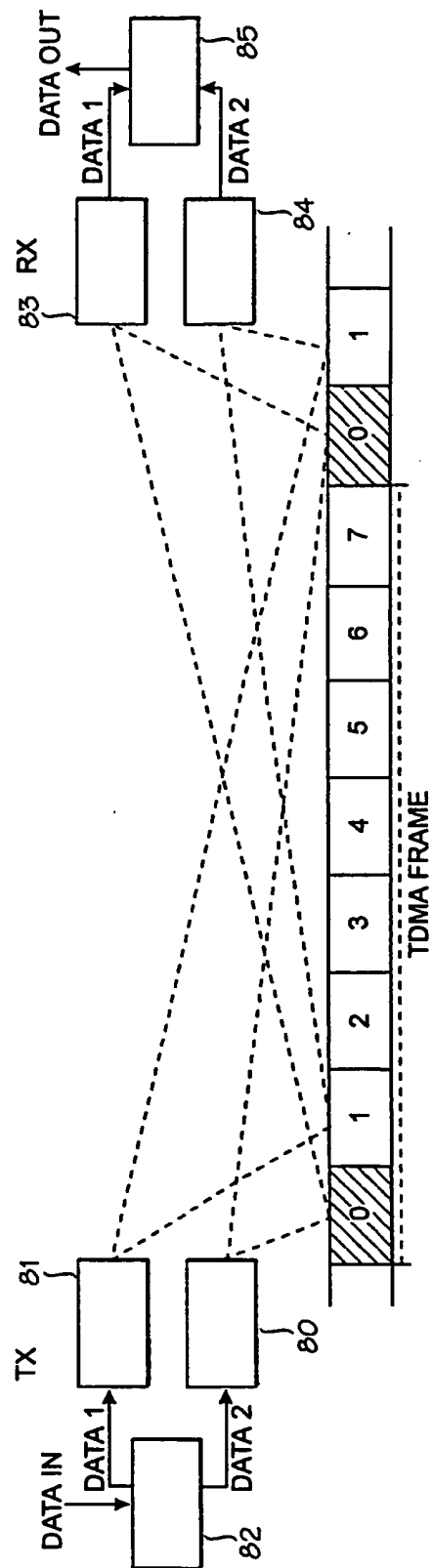


FIG. 8

1  
INTERNATIONAL SEARCH REPORT

International application No.  
PCT/FI 95/00248

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC6: H04Q 7/22

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q, H04B, H04J, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4905226 A (TSUNEO KOBAYASHI), 27 February 1990 (27.02.90), column 1, line 46 - line 52 --	1,6
X	US 4805167 A (IAN M LESLIE ET AL), 14 February 1989 (14.02.89), column 2, line 60 - line 67; column 4, line 1 - line 12 --	1,6
X	WO 9114319 A1 (NEW BRIDGE NETWORKS CORPORATION), 19 Sept 1991 (19.09.91), page 6, line 1 - line 22 --	1,6
X	EP 0516373 A1 (BRITISH TECHNOLOGY GROUP LTD), 2 December 1992 (02.12.92), page 3, line 58 - page 4, line 20 --	1,6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search

1 November 1995

Date of mailing of the international search report

02-11-1995

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

02/10/95

International application No.

PCT/FI 95/00248

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